8500A
Digital Multimeter

Instruction Manual

P/N 426536
July 1977

FLUKE®

WARRANTY

Notwithstanding any provision of any egreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in materiel and workmanship under normal use and service for the period of 1-yeer from date of purchase. This warrenty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

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If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use eny sultable contelner that is rigid end of adequate size. If a substitute container is used, the instrument should be wrapped in peper and surrounded with at leest four inches of excelsior or similar shock-ebsorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon originel delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immedietely. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC, will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WASHINGTON 98206, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

Rev. 6/81

Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. This manual is composed of eight sections containing the information necessary to install, operate, and maintain the Fluke Model 8500A Digital Voltmeter. The 8500A employs modular construction allowing numerous possible configurations. Your manual employs a modular construction designed to furnish you with the most up-to-date information possible. Sections 1 through 5 and 8 contain information relating to the 8500A mainframe, which includes the modules necessary for DC Volts and DC Ratio measurements. Section 1 contains a list of available options and a table of specifications for the mainframe. Section 2 is operating instructions, Section 3 is theory of operation, Section 4 is maintenance, Section 5 contains parts lists, and Section 8 contains schematic diagrams. Section 6 contains information relating to the options contained in your instrument, including the specifications, operating instructions, theory of operation, maintenance, parts lists, and schematics. As the need arises to expand your 8500A system, the most up-to-date information for the options you order will be included with them. Section 7 is general information: lists of abbreviations, federal supply codes, Service Centers, and Sales Representatives.

1-3. DESCRIPTION

1-4. Mainframe

1-5. The Model 8500A Digital Voltmeter is a six and one-half digit instrument employing microprocessor control and a bus structure. All active components are contained in modules which plug into a mainframe motherboard. The modules function under direct control of a microprocessor-based controller, which addresses each module as a memory location, similar to a computer. Modular construction allows considerable versatility in option selection and reduction of downtime by simple replacement of a faulty module.

1-6. The use of microprocessor control gives rise to "virtual" modules through arithmetic processing. External referencing and offsets, normally requiring separate circuitry, are performed by taking separate measurements, storing the values in memory, and operating on them arithmetically. Digital filtering is accomplished by taking a number of samples synchronous to the line frequency at a rate equal to an even multiple of the line frequency and averaging them for each reading. Limits and high/low peak detection are available through an optional remote interface.

1-7. Fluke's patented recirculating remainder (R^2) technique of A/D conversion has been adapted to microprocessor control. This method provides fast, accurate, linear measurements with long-term stability.

1-8. Options

1-9. A list of options available for the 8500A is contained in Table 1-1. Two ac converter options, an ohms converter option, and a current shunts option complete the analog capability of the 8500A. Three possible remote interfaces may be used for systems operation, but only one may be installed at a time. If a remote interface is installed, the isolator option must replace the interconnect pcb to maintain guarding of the analog and high-quality busses. The three remote interface options allow maximum versatility in interfacing the 8500A to digital systems. A calibration memory option reduces downtime due to calibration requirements. Correction factors for each range, derived from a standard input, may be entered from the front panel. Further measurements are then automatically corrected with the calibration factor. Table 1-2 is a list of accessories available for the 8500A.

1-10. SPECIFICATIONS

1-11. Specifications relating to the 8500A mainframe (DC Volts and DC Ratio measurements) are presented in Table 1-3. Specifications for the instrument with options are presented with the information relating to each option in Section 6. The table of specifications has been divided into two parts: Accuracy, and Instrument Operating Characteristics. Accuracy specifications have been consolidated for ease in reference both by the user in divergent

applications and by the metrologist in performance determination. Detailed instrument operating characteristics have been provided to assure exact knowledge of the Model 8500A performance in every unique situation.

Table 1-1. 8500A Options

Option No.	Name	Notes
01	AC/DC Converter (Averaging)	1,3
02	Ohms Converter	
03	Current Shunts	3
04	Calibration Memory	
05	IEEE Standard 488-1975 Interface	2
06	8it Serial Asynchronous Interface	2
07	Parallel Interface	2
08	Isolator	4
09	AC/DC Converter (True RMS)	1,3
17	Rear Input	

1) Options 01 and 09 cannot be installed simultaneously.
2) Only one of Options 05, 06, and 07 can be installed at any time.
3) For the AC portion of Option 03 to operate, either Option 01 or 09 must be installed.
4) Option 08 must be installed for remote operations.

Table 1-2. 8500A Accessories

Model or Part No.	Name
M04-205-600	Rack Ear Mounting Assembly
M00-260-610	18-inch Rack Slides
M00-280-610	24-inch Rack Slides
80F-5	High Voltage Probe
80F-15	High Voltage Probe
81RF	High Frequency Probe
82RF	High Frequency Probe
KDM1	Keyboard Display Module w/Cable
Y8001	IEEE Std. Cable, 1 Meter Length
Y8002	IEEE Std. Cable, 2 Meter Length
Y8003	IEEE Std. Cable, 4 Meter Length
MIS-7011K*	Extender Assembly
MIS-7190K*	Static Controller
MIS-7191K*	Test Module
MIS-7013K*	Bus Interconnect and Monitor

*For use during service or repair

Table 1-3. Specifications

ACCURACY

Note

The stated accuracies are valid under the following environmental conditions.

Temperature: 18°C to 28°C (Except 24 hour: 22°C to 24°C)

Humidity: ≤75%

Line Regulation: 90V to 110V, 103.5V to 126.5V, or 207V to 253V @ 45 to 66 Hz

DC Volts

Normal Resolution (Not in CAL Mode)					
Range	Full Scale	Resolution	Accuracy + (% of Input + Number of Digits)		
			24 Hours	90 Days	1 Yaar
100 mV	312 mV	1 uV	0.002 + 4	0.003 + 5	0.005 + 8
1 V	2.5 V	10 uV	0.001 + 1	0.002 + 1	0.004 + 1
10 V	20 V	100 uV	0.001 or 1*	0.001 + 1	0.002 + 1
100 V	160 V	1 mV	0.001 + 1	0.002 + 1	0.004 + 1
1000 V	1200 V	10 mV	0.001 + 1	0.002 + 1	0.004 + 1

*Whichever is greater.

Table 1-3. Specifications (Continued)

ACCURACY (Continued)

DC Volts (Continued)

High Resolution (In CAL Mode)

Range	Full Scale	Resolution	Accuracy ± (% of Input + Number of Digits)		
			24 Hours	90 Days	1 Year
1 V	2.5 V	1 uV	0.001 + 6	0.002 + 8	0.004 + 9
10 V	20 V	10 uV	0.001 or 6*	0.001 + 8	0.002 + 9
100 V	160 V	100 uV	0.001 + 6	0.002 + 8	0.004 + 9
1000 V	1200 V	1 mV	0.001 + 6	0.002 + 8	0.004 + 9

Whichever is less.

DC Ratio

Ext. Ref. Voltage	Accuracy
±20V to ±40V	±(A + B + 10 ppm)
$\pm V_{min.}$* to ±20V	$\pm\left(A + B + \frac{200\ ppm}{\lvert V_{xref} \rvert}\right)$

A =10V dc Range Accuracy
B =Input Signal Function and Range Accuracy
V_{min} =Minimum Allowable External Reference Voltage
$|V_{xref}|$ =Absolute Value of External Reference Voltage

The formula for determining V_{min} is included in Instrument Operating Characteristics

Example Calculations for External Reference Accuracy:

1. Input = + 90.000V, Ext. Ref. Input = 30.000V (+ 15V to Ext. Ref. HI, −15V to Ext. Ref. LO)
   A = .001% + 1 Digit B = .001% + 1 Digit
   Ratio Accuracy = ±(A + B + 10 ppm) = ±(.001% + 1 Digit + .001% +1 Digit + .001% = ±(.003% +2 Digits)
   Reading may be between 3.0003 and 2.9997

2. Input = 1.20000V, Ext. Ref. Input = .12000 (V_{min} for 1V Range)
   A = .001% + 1 Digit, B = .001% + 1 Digit, $\frac{200\ ppm}{V_{xref}} = \frac{.02\%}{.12} = .1667\%$

   Ratio Accuracy = ±.001% + 1 Digit + .001% +1 Digit + .1667%) = ±(.1687% + 2 Digits)
   Reading may be between .998313 and 1.001686.

INSTRUMENT OPERATING CHARACTERISTICS

DC Volts

TEMPERATURE COEFFICIENT (0°C to 18°C and 28°C to 50°C)

Range	Temperature Coefficient
100 mV	± (3 ppm/reading + 0.5 digit)/°C
1V	±(3 ppm/reading +0.1 digit)/ °C
10 V	± (2 ppm/reading + 0.05 digit)/°C*
100 V	± (3 ppm/reading + 0.1 digit)/°C*
1000 V	± (3 ppm/reading + 0.05 digit)/°C*

For High Resolution Multiply Digits by 10.

INPUT IMPEDANCE

Range	Input Impedance
100 mV	>10,000 MΩ
1V	>10,000 MΩ
10 V	>10,000 MΩ
100 V	10 MΩ
1000 V	10 MΩ
Guard to Chassis	5.6 MΩ

INPUT BIAS CURRENT

	At time of Cal	30 Days (23°C ± 1°C)	Temperature Coefficient
Bias Current	<± 5 pA	<± 50 pA	± 3 pA/°C

Table 1-3. Specifications (Continued)

INSTRUMENT OPERATING CHARACTERISTICS (Continued)

DC Volts (Continued)

RESPONSE TIME

Digitizing Time			Analog Settling Time Within Voltmeter		
Mode of Operation	Reading Rate	Digitizing Time	Filter Mode	Step Input to 0.01% of Change	Step Input to 0.001% of Change
Bench	50 Hz line 6-1/4 rdg/sec	162 ms	Bypassed Filter <100k Source Resistance (Remote)	2 ms	20 ms
	1-1/2 rdg/sec	642 ms			
	60 Hz line 7-1/2 rdg/sec	136 ms			
	1-7/8 rdg/sec	546 ms			
Remote	50 Hz 4 samples/rdg*	22 ms	Filter, Fast	40 ms	50 ms
	60 Hz 4 samples/rdg*	18 ms	Filter, Slow (Manual)	400 ms	500 ms

*Number of samples per reading is remotely programmable from 1 (2^0) to 131,072 (2^{17}) in 18 binary steps.

ZERO STABILITY

Better than 5 μV for 90 days after a one hr. warm-up. Front Panel pushbutton auto zero is provided. The zero correction is stored in memory until power is interrupted or the 8500A is RESET. If calibration memory Option –04 is installed, the zero correction is retained.

OVERLOAD

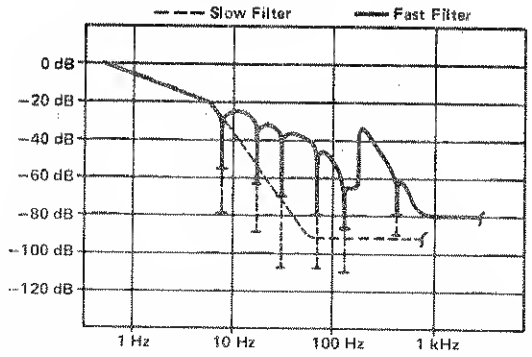
± 1200V DC to 60 Hz, or 1400V peak AC above 60 Hz may be applied continuously to any dc range without permanent damage. Maximum common mode rate of voltage rise is 1000V/μsec.

NOISE REJECTION

Normal Mode						Common Mode	
Line/Filter Frequency	4 Samples/ Rdg*	7-1/2 rdg/s	6-1/4 rdg/s	1-7/8 rdg/s	1-1/2 rdg/s	True	Effective
50 Hz Fast Filter	60 dB	N/A	70 dB	N/A	75 dB	100 dB at 60 Hz for 1 KΩ unbalance	Sum of Common Mode Rejection and Normal Mode Rejection
50 Hz Slow Filter	85 dB	N/A	90 dB	N/A	95 dB		
60 Hz Fast Filter	60 dB	70 dB	N/A	75 dB	N/A		
60 Hz Slow Filter	90 dB	95 dB	N/A	100 dB	N/A		

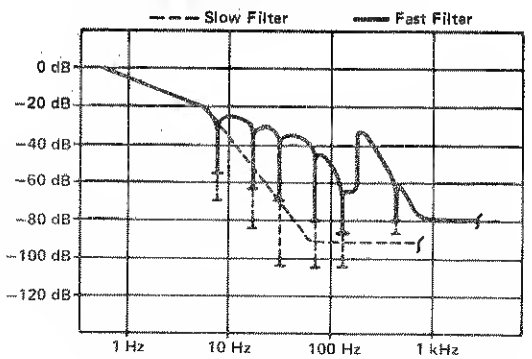
*Remotely selected

1-7/8 Readings/Second
Typical Performance with 60 Hz Line



Cusps shown are at multiples of 60 Hz line frequency

1-1/2 Readings/Second
Typical Performance with 50 Hz Line



Cusps shown are at multiples of 50 Hz line frequency

Table 1-3. Specifications (Concluded)

INSTRUMENT OPERATING CHARACTERISTICS (Continued)

DC Ratio

INPUT IMPEDANCE

Ext Ref HI or LO X 10,000 MΩ relative to Ohms Guard* or Sense LO

SOURCE IMPEDANCE

Resistive Unbalance (Ext Ref HI to LO) <4 kΩ

Total Resistance Sense LO from either HI or LO <20 kΩ

BIAS CURRENT

Ext Ref HI or LO relative to Ohms Guard* or Sense LO <5 nA

OVERLOAD (Ext Ref HI or LO)

±180 volts peak , 127V rms (relative to Ohms Guard* or Sense LO) X (360V peak HI to LO)

**Ohms Guard available through rear input option*

NOISE REJECTION

Normal Mode	Common Mode, All Inputs Driven
Sense Input—Same as dc volts	**Sense Input**—Same as dc volts
Ext Ref Input—dc, line frequency and 2x line frequency >100 dB	**Ext Ref Input**—Line frequency and 2x line frequency, 75 dB

RESPONSE TIME

Settling Time

Sense Input Fast Filter < 50 ms to 0.001% of change
Sense Input Slow Filter < 500 ms to 0.001% of change

Digitizing Time

NOTE

The Sense Input is measured prior to measuring Ext Ref HI and LO.

Ext Ref Input—Each input HI and LO

90 ms at 60 Hz line frequency
107 ms at 50 Hz line frequency

Ext Ref Calibration—12 ms

Sense Input			
Mode of Operation	Line Volt	Approx. Rdg. Rate	Digitizing Time
Bench	60 Hz	4½ rdg/s	136 ms
		1½ rdg/s	536 ms
	50 Hz	3½ rdg/s	162 ms
		1¼ rdg/s	642 ms
Remote	60 Hz	4 samples/rdg	18 ms
	50 Hz	4 samples/rdg	22 ms

EXT REF VOLTAGE RANGE

Maximum Ext Ref Voltage = ±40V between Ext Ref HI and LO terminals, providing neither terminal is greater than ±20V relative to the Sense LO or Ohms Guard terminals.

Minimum Ext Ref Voltage = ±0.0001V, or $\frac{V_{input}}{\text{Maximum Display within Range (See Table Below)}}$ (whichever is greater)

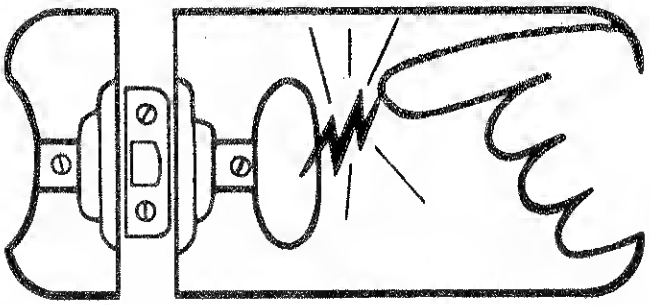
MAXIMUM DISPLAY—(Ratio/Scaling)

AC & DC VOLTS		AC & DC CURRENT		OHMS	
Range	Maximum Display (V/V)	Range	Maximum Display (A/V)	Range	Maximum Display (Ω/V)
100 mV	$\pm 999.999 \times 10^{-3}$	100 uA	$\pm 999.999 \times 10^{-6}$	10 Ω	±99.9999
1 V	±9.9999	1 mA	$\pm 9.99999 \times 10^{-3}$	100 Ω	±999.999
10 V	±99.9999	10 mA	$\pm 99.9999 \times 10^{-3}$	1 kΩ	$\pm 9.99999 \times 10^{3}$
100 V	±999.999	100 mA	$\pm 999.999 \times 10^{-3}$	10 kΩ	$\pm 99.9999 \times 10^{3}$
1000 V	±1279.99	1 A	±1.2799	100 kΩ	$\pm 999.999 \times 10^{3}$
				1 MΩ	$\pm 9.99999 \times 10^{6}$
				10 MΩ	$\pm 99.9999 \times 10^{6}$
				100 MΩ	$\pm 999.999 \times 10^{6}$

static awareness

A Message From

John Fluke Mfg. Co., Inc.

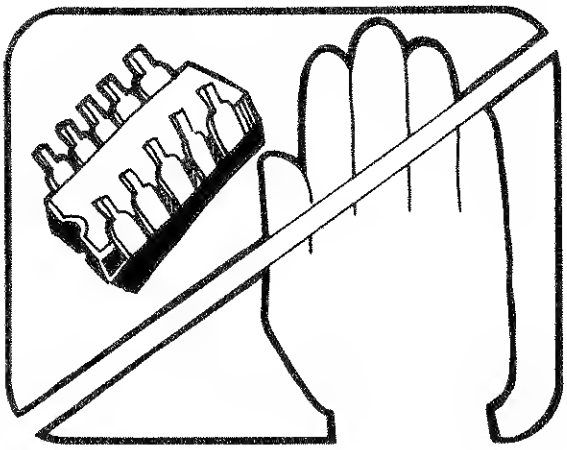


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

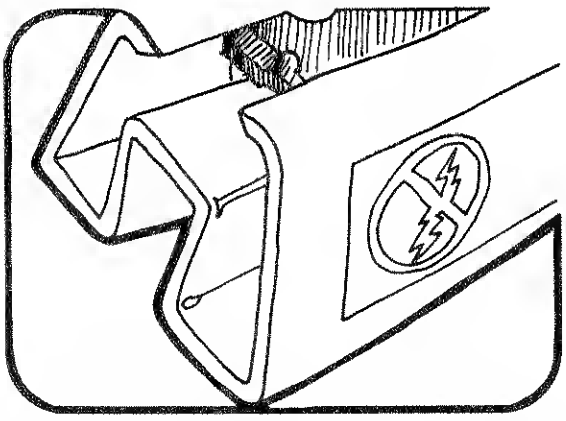
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

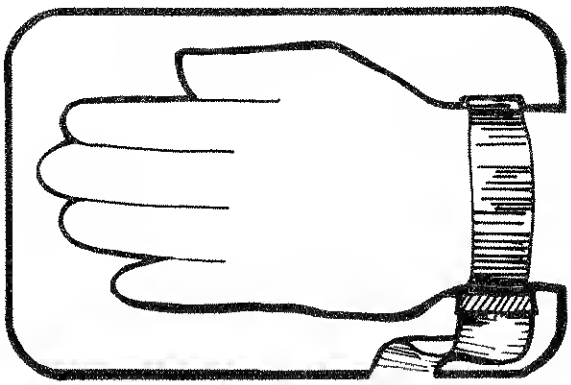
The following practices should be followed to minimize damage to S.S. devices.



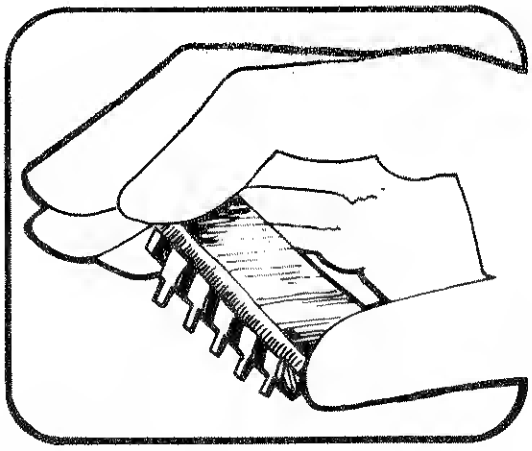
1. MINIMIZE HANDLING



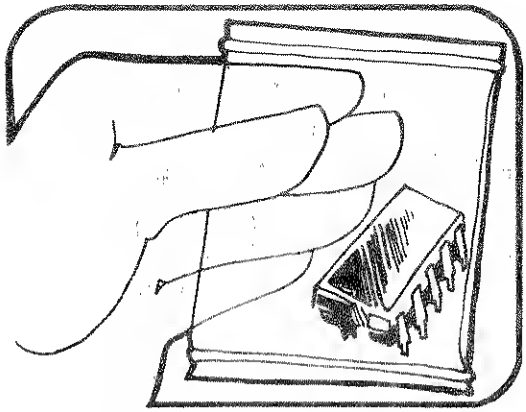
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



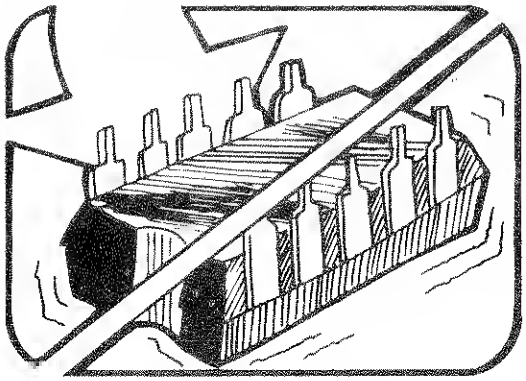
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



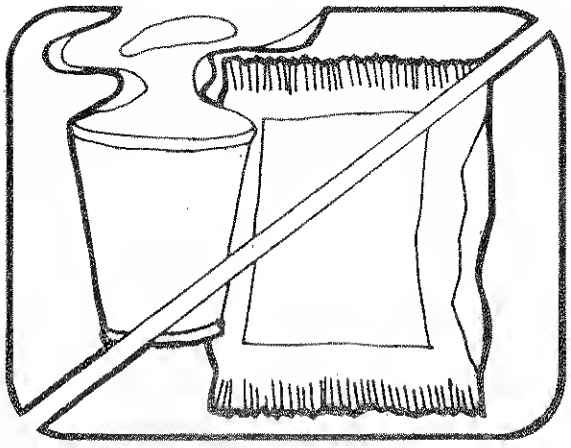
4. HANDLE S.S. DEVICES BY THE BODY



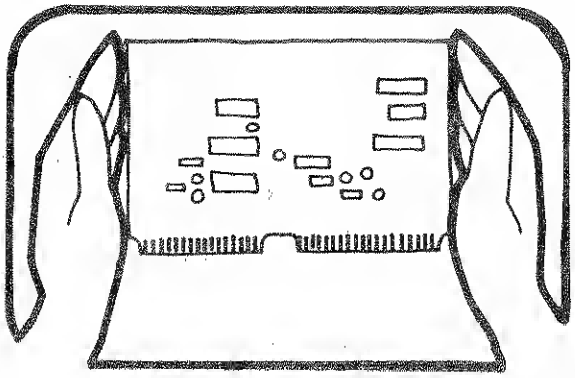
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



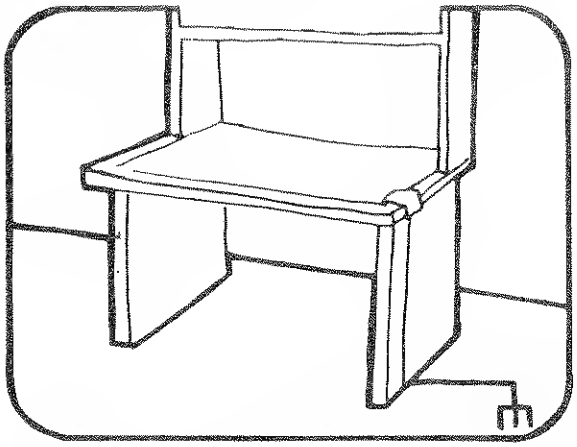
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR USUALLY PROVIDES COMPLETE PROTECTION TO INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Description
680892	5" x 8" Bag
680934	8" x 10" Bag
680942	8" x 12" Bag
680983	12" x 16" Bag
681023	18" x 18" Bag
Pink Poly Sheet 30" x 60" x 60 Mil P/N RC-AS-1200 $20.00	Wrist Strap P/N TL6-60 $7.00

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Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section of the manual contains information regarding installation and operation of the Model 8500A Digital Voltmeter. It is recommended that the contents of this section be read and understood before any attempt is made to operate the instrument. Should any difficulties arise during operation, contact your nearest John Fluke Sales Representative or the John Fluke Mfg. Co., Inc.; P. O. Box 43210; Mountlake Terrace, WA 98043; telephone (206) 774-2211. A list of Sales Representatives is located in Section 7 of this manual.

2-3. SHIPPING INFORMATION

2-4. The 8500A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included with the shipping container.

2-5. If reshipment is necessary, the original container should be used. If the original container is not available, a new container can be obtained from the John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INSTALLATION

2-7. Non-marring feet and a tilt-down bail are installed on the instrument for field or bench use. A rack-mounting kit and rack slides are available for use with standard 19-inch equipment racks. Information regarding installation of rack-mounting accessories is contained in Section 6.

2-8. Input Power Requirements

2-9. The 8500A operates from either 115V ac ± 10% or 230V ac ± 10%, 50 or 60 Hz (103.5 to 126.5V ac, or 207 to 253V ac, 45 to 66 Hz). The line voltage that the 8500A is operated from must be within the specified tolerance. A binding post on the rear panel has been provided to assure a proper earth ground connection. Section 4 contains instructions for switching the power supply from accepting 115V ac to 230V ac or vice versa. Operation at 50 Hz is the same as at 60 Hz except for slower response times.

CAUTION

Unless the chassis of the 8500A is properly grounded, the possibility of electrical shock may occur when measuring high ac voltage with the leads reversed (Input HI grounded). The ground connection has been provided in the three-prong connector.

2-10. Fuses

2-11. The line fuse is located on the rear panel near the heatsink. Use a ½ A MDL (slow-blow) fuse for replacement. The current protection fuse is located in the lower right-hand corner of the front panel. Use an AGC 1½ A replacement fuse.

2-12. OPERATING FEATURES

2-13. The location and function of all 8500A controls, indicators, and connectors are shown in Figure 2-1 and described in Table 2-1.

2-14. OPERATING NOTES

2-15. General

2-16. Upon applying power to the 8500A, the display will read "HI" and then the option configuration (Cxxxxx, where x is the installed option number). During this period a function and range may be selected; if not, the instrument will place itself in the DC Volts function, 1000V range. All front panel switches except the power switch and the CAL switch are momentary contact switches. If a switch is held in continuously, it will be "read" only one time (automatic debouncing). For rated measurement accuracy, the 8500A should be allowed to warm up for one hour.

2-17. The display consists of five and one-half digits with an exponent to give readings in engineering notation. Decimal placement and reading and exponent polarity are automatically provided. If desired the exponent may be replaced by an extra digit of resolution (refer to the explanation for the CAL mode switch later in this section).

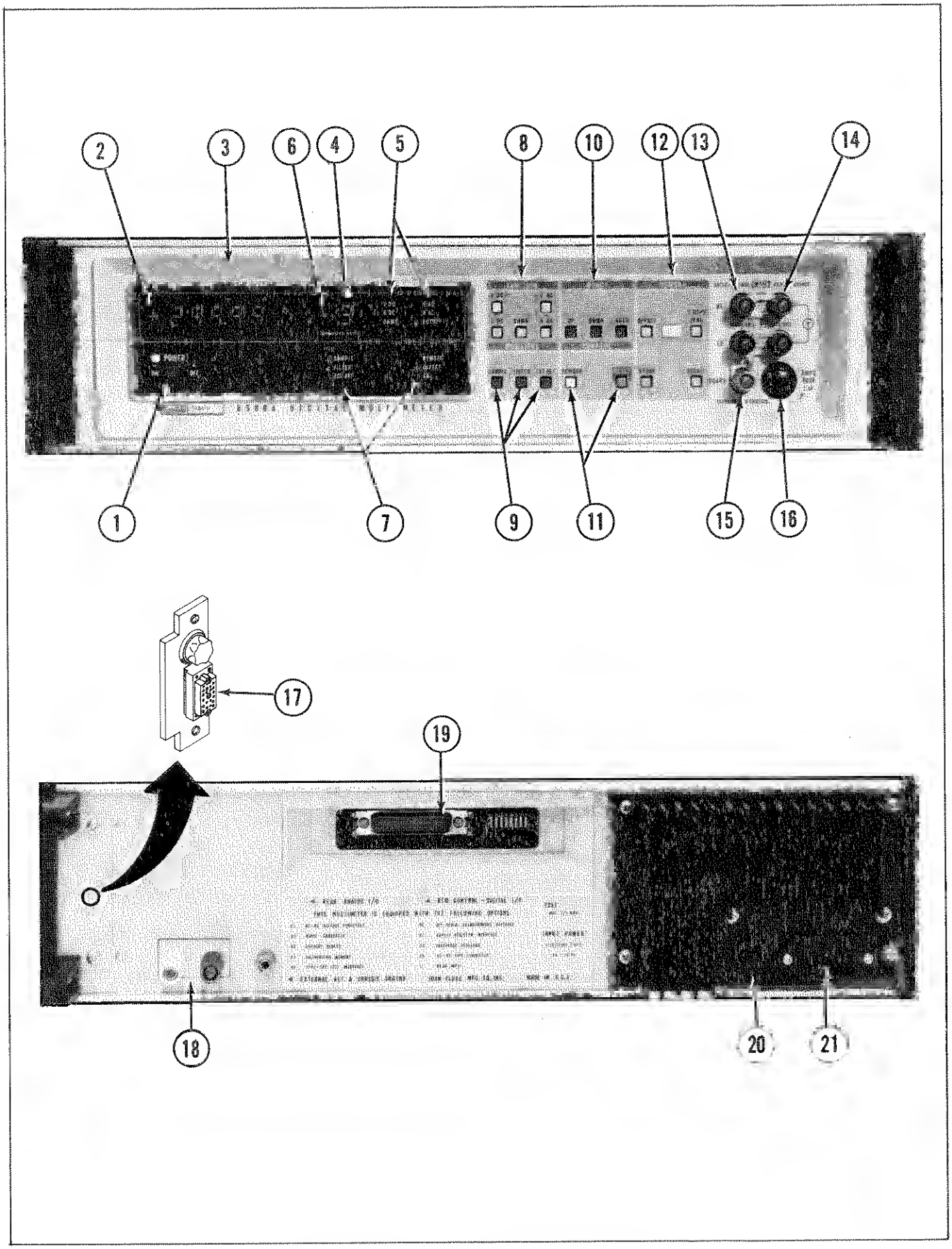


Figure 2-1. 8500A Controls, Indicators, and Connectors

Table 2-1. 8500A Controls, Indicators, and Connectors

REF. NO.	NAME	FUNCTION
1.	Power Switch	Push on/Push off for line power
2.	Polarity Display	Displays polarity of readings when appropriate
3.	Digit Display	Displays value of reading with properly positioned decimal
4.	Exponent Display	Displays exponent for engineering notation
5.	Range and Function Indicators	LEDs illuminate to indicate function selected and whether or not in autorange
6.	Modifier Indicators	LEDs illuminate to indicate modifiers selected, sample indicator blinks at reading rate selected
7.	Control and Memory Indicators	LEDs illuminate to indicate status of remote, offset, and CAL modifiers
8.	Function Switches	Selects function—DC Volts, AC Volts, DC and AC Volts, DC Current, AC Current, and Ohms. Optional modules must be installed for other than DC volts. Error 9 will be displayed if a function is selected for which the module is not installed
9.	Modifier Switches	Selects samples/rdg rate, filter (fast or slow) and external reference
10.	Range Switches	UP and DOWN change the range one range at a time, AUTO selects or disables autoranging
11.	Control Switches	REMOTE toggles control from front panel to remote-selecting remote disables all front panel switches except POWER and REMOTE. RESET initiates a master program restart (to the beginning)
12.	Memory Switches	OFFSET, VDC/Ω ZERO, STORE, and CAL are used to place values into memory for computations. ZERO and CAL factors are applied automatically. OFFSET function must be selected separately from entering a value into memory. CAL may be used to obtain an extra digit of resolution in all but the lowest range. RECALL is used to display a previously entered CAL, OFFSET, or DC ZERO factor.
13.	Input VOLTS/Ω Sense Terminals	HI and LO connections for DC and AC voltages and Ohms measurements
14.	Input AMPS/Ω Source Terminals	HI and LO connections for Current and Ohms measurements
15.	Guard Terminal	For guarded measurements (should always be connected)
16.	Current Fuse	Use a 1½ Amp Fast Blow Fuse
17.	Parallel Rear Analog Input Terminals	Optional terminals having same functions as those on front panel with the addition of an Ohms guard terminal
18.	Ext Ref Terminals	Input for external referencing
19.	Interface Connector and Switches	Connector and address switches installed on a remote interface module accessible through the rear panel
20.	Line Fuse	Use an MDL ½ (slo-blow)
21.	AC Line Voltage Connector	Three-prong connector accepting line cord with ground wire

2-18. Function Selection

2-19. A function may be selected simply by depressing the switch for the desired function. DC volts is standard with the 8500A mainframe. For ac volts, dc or ac current, and ohms functions, optional modules must be installed in the 8500A. Operations peculiar to each function will be explained in Section 6. If a function is selected for which the option is not installed, Error 9 will be displayed.

2-20. Error Codes

2-21. The Front Panel display and the optional interface output will indicate an error by displaying an Error Code. For operator convenience, a pull out tab, under the instrument on the right side, contains a set of condensed operating instructions which lists the errors associated with the various codes. The codes and the errors causing them are listed in Table 2-2. If the CAL mode is selected, Error Codes will not be displayed. Any function may be selected, and if the module is not installed, random readings will be displayed.

2-22. DC Voltage Measurement

2-23. The Model 8500A mainframe measures dc volts in five ranges (100 mV to 1000V). Resolutions from 1μV on the lowest range to 1 mV on the highest range are available. Overrange or full-scale capabilities progress in an octal relationship from 312 mV on the lowest range to 1200V on the highest range. All ranges are completely protected from overload conditions as specified in Section 1. Input impedance is greater than 10,000 megohms in the 100 mV, 1V, 10V ranges; 10 megohms in the 100V and 1000V ranges. DC voltage accuracies are specified in Section 1.

2-24. Input Terminals

2-25. For dc voltage measurements, the Input HI terminals may be left strapped together and the Input LO terminals may be strapped together. For most measurements it is sufficient to strap the guard terminal to the Input LO terminal. Shorting links have been provided for making these connections. A more complete description of the use of the guard terminal is included later in this section. Do not ground the Input HI terminal and drive the LO terminal as the guard bleeder resistor will reduce the input impedance to 5.6 MΩ.

CAUTION

The guard terminal should not be left disconnected as common mode voltages may exceed the LO to guard voltage rating, possibly resulting in damage to the instrument.

2-26. Range Selection

2-27. Autoranging may be selected by depressing the AUTO switch. When autoranging is selected, the AUTO LED in the display will light. Depressing the AUTO switch again will select manual ranging without changing the range. Depressing the UP or DOWN switches will also select manual ranging while changing the range one at a time in the desired direction. When the voltage at the input terminals exceeds the full-scale value for a range, the digit display will flash HHHHHH on and off at the sample rate unless the cal mode has been selected. When a valid function switch is depressed, the instrument automatically shifts to autoranging.

Table 2-2. Error Codes

CODE	FAULT
Error	System error – if the error message appears prior to the introductory messages at power initialization or reset, the problem is with the calibration memory module.
Error 0	VDC/Ω Zero Error – either a VDC/Ω Zero was attempted in a range other than 100mV or 10Ω, or an overrange value was entered.
Error 1	Offset error – either down ranging was attempted past the range of the offset, the offset was recalled in a different function than was stored, or it was toggled into offset in a function where an offset value was not stored.
Error 2	Filter Module error – the Module is faulty or not installed.
Error 3	DC Signal Conditioner error – the Module is faulty or not installed.
Error 4	Ohms or Current error – excessive voltage applied to the selected module, shorting links not properly connected, or the selected module is faulty.
Error 5	R^2 A/D error – the recircuitating remeinder analog to digital converter module is faulty or not installed.
Error 6	Numeric display overflow error.
Error 7	External reference error – the magnitude of one of the ext ref inputs is greater than 20V dc.
Error 8	Controller error – the module is faulty or not installed.
Error 9	Function Selection error – the function module selected, other than dc volts, is faulty or not installed.

2-28. Modifier Selection

2-29. SAMPLE RATE

2-30. Two sample rates are available from the front panel: 128 samples/reading and 32 samples/reading. The resulting reading rates are approximately 2 readings/second and 8 readings/second respectively for a 60 Hz line frequency (6 rdgs./sec. and 1½ rdgs./sec. for 50 Hz operation). Samples are taken syncronous to the line frequency so the greatest line noise rejection is at the 2 readings/second rate. (The larger the number of samples averaged the greater the line noise rejection.) The SAMPLE indicator LED flashes at the rate the readings are being taken.

2-31. FILTERING

2-32. The front panel FILTER switch selects either a fast filter or a slow filter. Fast and slow refer to the settling times required for each filter. When the FILTER LED is illuminated, the slow filter has been selected. The slow filter has a faster roll-off below 60 Hz and provides better normal mode noise rejection at 60 Hz than the fast filter. The fast filter discriminates against higher frequency and harmonically-related line noise and should be used when faster settling times for stepped input functions are required and where noise is not a problem.

2-33. EXTERNAL REFERENCE

2-34. The external reference feature may be used to divide an input to the input terminals (any function) by the value of dc voltage applied to the External Reference input terminals located on the rear panel.

$$\text{Reading} = \frac{\text{Input}}{\text{dc Ext. Ref. Input}}$$

This is a true ratio measurement arrived at by measuring the values at the two sets of input terminals. Then the reading is computed by the microprocessor in the Controller Module. The External Reference terminals will only accept a dc voltage. The maximum value which may be applied is ± 20V to either terminal with respect to the SENSE LO terminal or ohms guard [on the optional rear panel input terminals (Option −17)] A connection must be made from Sense LO to either External Reference HI or LO having a total resistance of less than 20 kΩ. So a maximum of 40V may be applied between the external reference terminals. The minimum voltage which may be applied is ±100 μV or the absolute value of the input to the Volt/Ω terminals divided by the maximum display within the input range when in the external reference mode, whichever is greater. A table of the maximum displays for each range when in the external reference mode is included in the specifications in Section 1.

$$V_{min} = \frac{|\text{Vinput}|}{\text{Maximum Display Within Range}}$$

Example: Voltage applied to the Volt/Ωterminals = −8.0000 V

Maximum Display Within 10V range (ext ref mode) = ±99.9999

$$V_{min} = \frac{8.0000\text{V}}{99.9999} = .0800001\ \text{V}$$

2-35. External reference is selected by depressing the EXT REF switch. If the switch is held in, the display will read out the value of dc voltage applied to the External Reference terminals (this value is displayed only when selecting the external reference mode). The external reference mode is turned off by depressing the EXT REF switch again.

2-36. Two examples of accuracy determination have been included in the specifications in Section 1. These examples are of most use to a metrologist in that known inputs were used and allowable deviations were the results. The following is an example of determining a pure percentage (without ± digits) to be applied to unknown inputs.

Measured Volt/Ω input = 9.0000V

Measured Ext. Ref. input = 2.0000V

$$\text{Accuracy} = \pm\left(A + B + \frac{200\text{ ppm}}{|\text{Vxref}|}\right)$$

where A = 10V dc range accuracy
B = Input signal function and range accuracy
|Vxref| = Absolute value of external reference input

A = .001% + 1 digit $\quad \frac{200\text{ ppm}}{\text{Vxref}} = \frac{.02\%}{2}$

B = .001% + 1 digit

A & B = .002% + 2 digits

$\frac{200\text{ ppm}}{|\text{Vxref}|}$ = .01%

Accuracy = .012% + 2 digits

Translating digits to percentage:

Ratio Reading = 4.5000
(Same number of digits behind decimal as in maximum range reading)

2 digits is .0044% of 4.5000 $\quad \left(\frac{.000044}{4.5\sqrt{.0002}}\right)$

Accuracy expressed as a percentage = ±.0164%

2.37. Safety Warning Indications

2-38. In the external reference and offset modes when an input at the terminals exceeds 40 volts, the exponent figure flashes the symbol "H" to warn the operator that a more dangerous voltage is present at the input than is displayed by the 8500A. If the CAL switch is in the Cal mode position (CAL indicator illuminated) no indication of warning is given. An example would be when the external reference input is equal to 10 volts and the input at the terminals is 50 volts. This gives a reading of 5 volts which does not show the operator that a potentially dangerous voltage is present on the input terminals. The flashing indicators are a warning only. They have no effect on the operation of the instrument.

2-39. Control

2-40. Depressing the REMOTE switch places the instrument in remote control. When in remote, only the REMOTE switch and the POWER switch will have any effect on the operation of the instrument. Depressing the REMOTE switch a second time or briefly removing the power will return the instrument to front panel control. When placed in remote, the operation of the instrument will cease (except the display) until new commands are received through an optional remote interface.

2-41. The RESET switch is used to start the main program over again. The display will read out "HI" and then the option configuration. If a function or range is not selected during this period, the instrument will place itself in the DC Volts function, 1000V range.

2-42. Memory

2-43. OFFSET

2-44. The OFFSET switch is used to select or disable the offset mode. In the offset mode, whatever offset value has been entered into memory will be automatically subtracted from subsequent readings. To enter an offset value into memory, first apply that input value (any function) to the Volt/Ω input terminals. Depress the STORE switch. A "?" will be displayed. Then depress the OFFSET switch. The value applied to the input terminals is now entered in memory. The instrument may already be in the offset mode when entering a value into memory. If not, entering a value into memory will not place the 8500A into the offset mode. The offset function cannot be selected in a range lower than the one in which an offset value was placed in memory.

2-45. VDC/ΩZERO

2-46. Zeroing is performed by the 8500A as an automatic operation. Separate zero values may be stored for VDC and ohms functions (provided the ohms option module is installed). Zero values or correction factors are entered by depressing the STORE switch, then the VDC/Ω ZERO switch. The instrument must be in the lowest range (100 mV or 10 Ω). Any internal drift may be corrected for with the zero functon by placing a good quality short on the input terminals (HI to LO) and depressing the STORE switch, then the VDC/Ω ZERO switch.

2-47. CALIBRATION MODE

2-48. The calibration mode may be used to perform two functions: adding an extra digit of resolution (except in the lowest range) and entering calibration factors for each function and range (the optional calibration memory Option –04 must be installed). The CAL switch is accessible through a hole in the front panel. A small plastic cover pops out and hinges down. Using a small screwdriver or similar tool, push the slide switch down to enter the Cal mode. The CAL LED will light to indicate that the instrument is in the Cal mode. The exponent display is used for the extra digit of resolution so the exponents are lost (except the exponent polarity). Placing the instrument in the Cal mode disables the Error Code function. Any function may be selected and if the option is not installed, random readings will be displayed. If the Cal memory option is installed, inadvertently depressing the STORE switch will erase the calibration factor for whichever function and range the instrument was in. Refer to Section 6 for further instructions about the Calibration Memory option.

2-49. STORE and RECALL

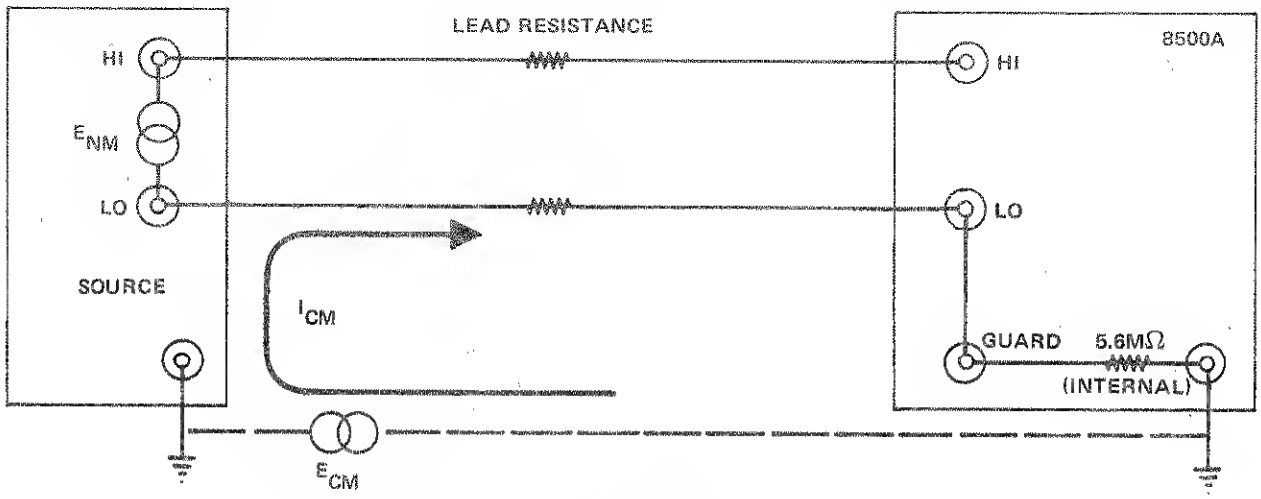
2-50. The STORE switch is used to enter values into memory (Offset, CAL, VDC/Ω Zero) as previously explained. Recall may be used to display a stored value. First depress the RECALL switch, then the desired value switch (OFFSET or VDC/Ω ZERO). Ohms zero values cannot be recalled. The value will be displayed as long as the switch is held depressed. The value displayed will be presented in the resolution of the range the instrument was in when the RECALL switch was depressed.

2-51. Guarding

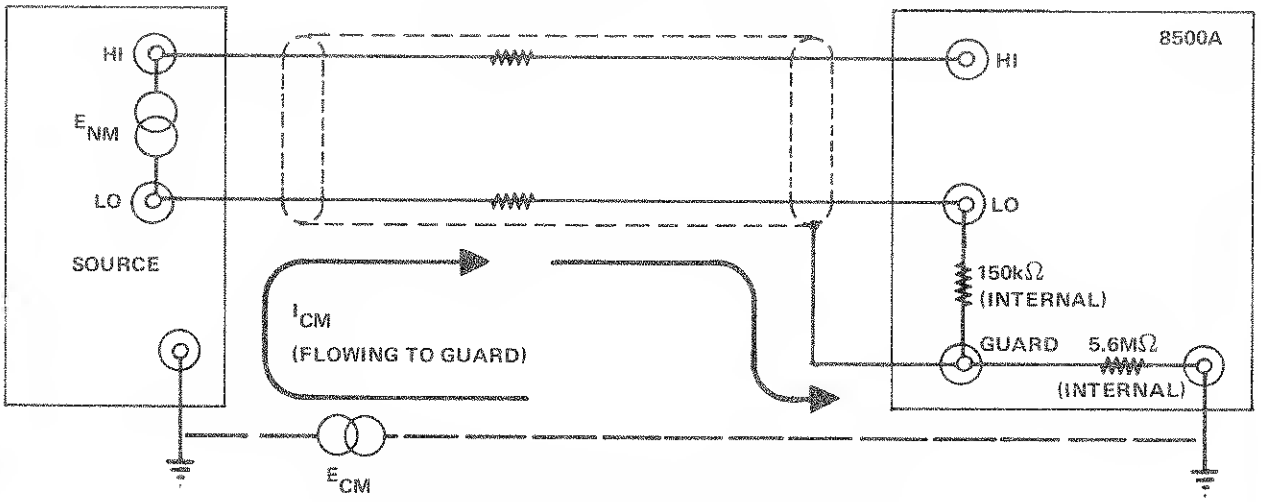
2-52. Common mode voltages are differences in potential that exist between two points that are grounded or common due to voltage drops along the ground wires or to currents induced into them. Normal mode voltages are the voltages and noise of a source to be measured. Common mode voltages may induce current flow through test leads and possibly through the internal impedance of the DVM, producing significant errors. The use of a floating, guarded voltmeter will minimize common mode errors but only if the input and guard connections are made properly. Figure 2-2 shows possible ways of connecting the 8500A to minimize common mode errors. There are two important considerations in using the guard connection. Connect the guard terminal for minimum difference of potential between the guard and input LO terminals. The input LO to guard maximum voltage rating of the 8500A is 100V. Connect the guard to minimize common mode currents flowing through any resistance which helps determine the voltage being measured.

CAUTION

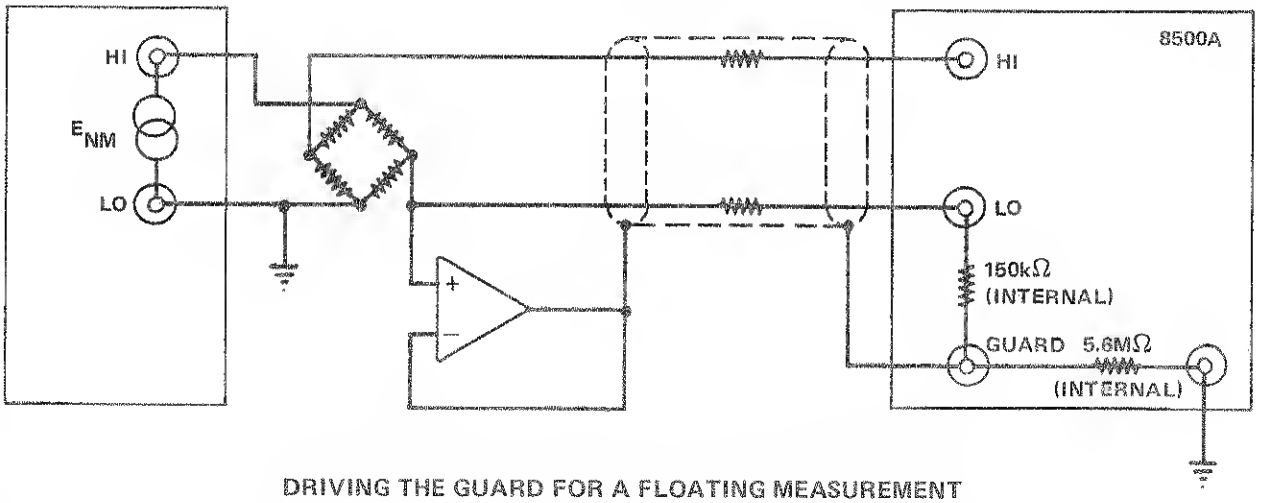
The guard terminal should always be connected either to the input LO terminal or to a point in the source circuit to be measured. With the guard terminal left open, common mode voltages may exceed the input LO to guard breakdown voltage, possibly damaging the instrument.



FOR NONCRITICAL MEASUREMENTS – E_{CM} ERROR PRESENT



E_{CM} ERROR MINIMIZED – I_{CM} FLOWS THROUGH SHIELD INSTEAD OF THROUGH TEST LEADS



DRIVING THE GUARD FOR A FLOATING MEASUREMENT WHICH MAY BE LOADED BY DIRECT CONNECTION OF THE GUARD

Figure 2-2. Guard Connections

2-53. The following conditions are examples of situations in which guarding should be employed:

a. When long signal leads are used.

b. When the signal source impedance is high.

c. When making floating measurements.

d. When making measurements in the presence of high-level noise, such as power line radiation.

2-54. Thermal EMFs

2-55. When making low level, high resolution measurements, the possibility for error due to thermal EMFs should be considered. Generally, thermal EMFs are voltages produced by temperature differences between contacts of two dissimilar metals or by temperature gradients along a length of a material. In some circumstances differences in potential of several microvolts may exist. Input terminals of the 8500A are gold-plated. The use of low EMF, shielded cables with gold-plated spade lugs will minimize thermal EMF errors.

2-56. Systems Use of the 8500A

2-57. Remote interface options are available which will enable the user to interface the 8500A to a large variety of digital systems. All operating and programming instructions relating to remote operation are included in Section 6.